JEHLE

Deflection of machine tools under stress

Mechanical Engineering

B. S.

1910

UNIV. OF
ILLINOIS
LIBRARY

UNIVERSITY OF ILLINOIS
LIBRARY

Class 1910
Book J38
Volume

Mr10-20M

DEFLECTION OF MACHINE TOOLS UNDER STRESS

S10
251
Gd.O.
C

BY

FERDINAND JEHLE

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE

IN MECHANICAL ENGINEERING

IN THE

COLLEGE OF ENGINEERING

OF THE

UNIVERSITY OF ILLINOIS

JUNE, 1910

1510
J38

1910
J38

1.— 28F11 Craig.

UNIVERSITY OF ILLINOIS

May 31 1910

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Ferdinand Jehle

ENTITLED Deflection of Machine Tools under Stress

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Mechanical Engineering

J. H. Gill
Instructor in Charge.

APPROVED: G. A. Goodenough

HEAD OF DEPARTMENT OF Mechanical Engineering

167536

THE RARE BOOK &
UIUC
MANUSCRIPT LIBRARY

TABLE OF CONTENTS

	Page.
Discussion	1.
Table	6.
Drawings	7.
Photographs	12.

Digitized by the Internet Archive
in 2016

https://archive.org/details/deflectionofmach00jehl

DEFLECTION OF MACHINE TOOLS

UNDER STRESS

This thesis was to be a continuation of the one submitted by Warren Moore Mansfield in 1909. It was to consist of the determination of the deflections of different machine tools due to the stresses caused by taking a cut on the work. This deflection was to be measured with the deflectometer designed by Mr. Mansfield for this purpose.

The above mentioned Deflectometer consisted of a frame upon which a carriage was made to slide along horizontal guides. The carriage was drawn along its path by means of a cord which was attached to it and passed aroung a small drum, driven by the driving mechanism of a Columbia Phnnograph. A glass plate 1"x 3"x 1/16" (a microscope slide) was fastened to this carriage upon which a record was scratched by a carborundum point. This carborundum point was fastened to a vertical plunger working thru a lapped hole in the top of the frame. The frame was held stationary while the plunger was fastened to the machine to be tested by means of a small rod, thus transmitting the vibrations of the machine to the recording point.

The frame of the instrument was held stationary in the following manner. Two 3" channels, 7' long, were bolted back to back with spacing pieces to hold them 3/4" apart. Two cast iron blocks with the tops the shape of Vs were placed on the channels a certain distance apart, and the whole clamped securely to the bottom side of the lathe bed to be tested, by means of bolts. The glass plate was then allowed to pass underneath the recording point, thus drawing a datum line. It was then brought back to its starting position. A heavy cut was taken and during this, the plate was again drawn along its ways and another line drawn. The distance between these two lines was the deflection for that span and was read with a microscope.

Several improvements were suggested by Mr. Mansfield, chief among which was the design of some better means for adjusting the pressure of the recording point on the glass plate. The carborundum point was set in a screw which in turn was screwdd into the spring at the end of the plunger. By adjusting the screw the point could be made to bear with any desired pressure upon the record plate. One difficulty, however, was encountered. The carborundum point would cut best only in one direction, and hence, if the point did not bear enough on the plate, the screw had to be given one complete revolution. Now since the screw had on it a number 40 thread, this meant that the point had to be brought 1/40" closer to the plate. This, naturally, for most conditions was too much. To overcome this difficulty the carborundum point was mounted in a smooth brass rod about 3/32" x 1" and clamped at the end of the plunger spring with a device similar to that with which the lead is held in a Deitzgen compass. For regulating the pressure a micrometer adjustment was provided. This is shown in detail in the drawings included in this thesis.

With this improvement the instrument was assembled and prepared for a preliminary test. For this purpose the instrument was held in a vise and the plunger clamped in a permanent position by means of a common iron clamp. A datum line was drawn by setting the instrument in motion. The point was then raised by simply lifting the plunger spring and the carriage brought back to its initial position. Then without apparently changing any of the adjustments, the instrument was again started and another line drawn which should have coinsided exactly with the first. This result was not obtained. Several trials were taken and it was found that it was a comparatively easy matter to draw two lines, with apparently the same adjustment, which were not coincident even to the naked eye.

This may be attributed to the following reasons.

1. The lost motion in the ways of the carriage due to inaccurate workmanship. The instrument was not made very carefully.

2. The fact that the strings which pulled the slide did not remain in the same straight line with the center line of the slide.

3. The adjustments may have been changed, unknowingly, by moving the slide back to its starting position.

4. Starting the carborundum point in its same cut may have ruined its original point, and thus a newly formed point may have cut the second line.

For these reasons it was thought best, or rather necessary, to construct a new instrument. The first of the above mentioned reasons for inaccuracies could have been remedied by constructing the slide with greater care. The remedy for the other three, however, seemed only to be found in a new design.

Various possible schemes were considered and it was finally determined that the record plate should be revolved instead of moving

along a straight path. The glass plate was clamped to a circular disc. This disc was fastened to a shaft which had a conical bearing at one end and a cylindrical one at the other. A spring served to hold the shaft in its bearing. Motion was transmitted from the phonograph driving mechanism by means of a train of friction gears. It was so arranged that the mechanism could be allowed to accelerate up to uniform motion and the friction gears then thrown in to rotate the record plate. To draw the zero line the disc was allowed to rotate, but it was stopped before one revolution was completed. This was done so that the record point did not have to start its new record in its old scratch, which could seriously injure it. A diamond point was used instead of the carborundum. A graph now had the appearance as shown in the sketch. The black line is the datum or zero line while the red one is the record taken during the cut.

The Pratt and Whitney High Speed lathe was used for this test. The apparatus was attached to the machine exactly as described in a previous paragraph. The test piece was a piece of steel four inches in diameter and four feet long, the same that was used by Mr. Mansfield. The cutting speed was measured with a cutmeter. The depth of the cut was measured with a scale divided into hundreds. To determine the speed of the feed, a record was kept of the notch the feed lever was in, and a separate test run to convert these readings into feet per minute. The inverted Vs were placed on the channel iron 58" apart and the instrument fastened exactly in the center. The cut was taken over the center of the span. The record therefore shows the maximum deflection of the bed under the cut for a span of 58".

The deflections were measured with the aid of a graduated

eye-piece of a high power microscope. The eye-piece graduations were first calibrated by comparing them with a stage micrometer graduated to 1/100 milimeters. It was found that 16 divisions of the eye-piece graduations corresponded to 5 of the micrometer. Thus one division on the eye-piece scale was equal to 5/(16x100) or .003125 milimeters. Reducing this to inches we get;

.003125 mil. eQuals .003125 x .03937 or .000123"

Ten readings were taken on every record and an average of these is given in the accompanying table.

The deflections shown in the table are only for those places on the record where the graph is rather smooth, and where the vibrations do not cross the datum line. The first record showed a line with numerous vibrations none of which crossed the datum. In the second the vibrations occasionally crossed the datum line and the same holds true for number three. The fourth record was not a very good one. The scratch was too coarse in most places, so that the first and second graphs overlapped eachother. At the places where they could be distinguished, the vibrations were enormous compared to those which the other records showed. Record number five was worthless since the graphs were too coarse. The sixth and last record is rather interesting. Only in a few places do the vibrations not cross the datum line. Undoubtedly this is due to the chattering of the tool. It was noted that while this record was being made much chattering was going on. Some parts of various records were photographed together with a milimeter scale divided 1/100. From this some idea as to the nature and size of the deflections can be obtained.

It is hoped that this subject will be further investigated in the near future and other machine tools, such as, planers and milling-machines will be tested in this or a similar way. On page 545,

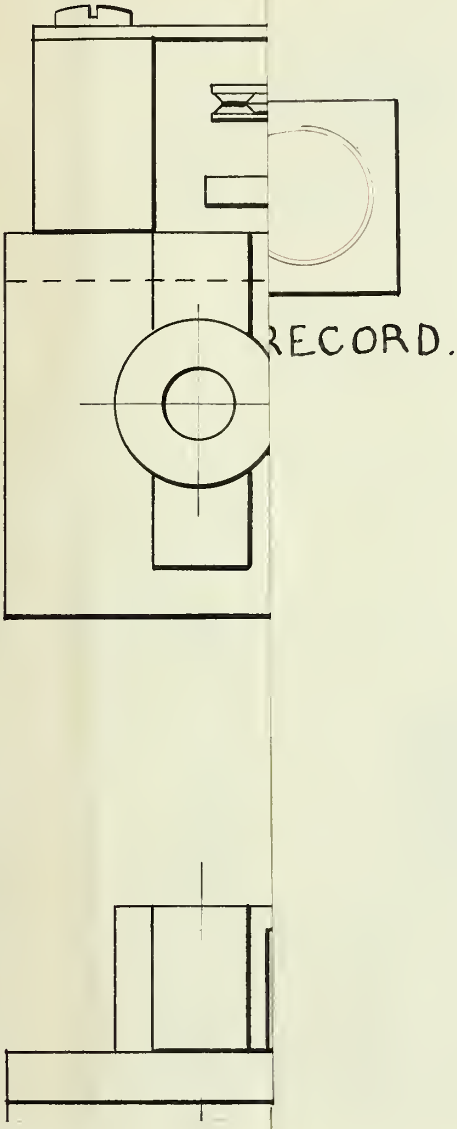
Volume 31, of the American Machinist, there is an article entitled, "Rigidity Test of a 24x24 inch 8 foot Planer," by James A. Pratt. It might be well to test a planer under similar conditions as therein discribed but by a different method, since the one employed by Mr. Pratt seems rather crude.

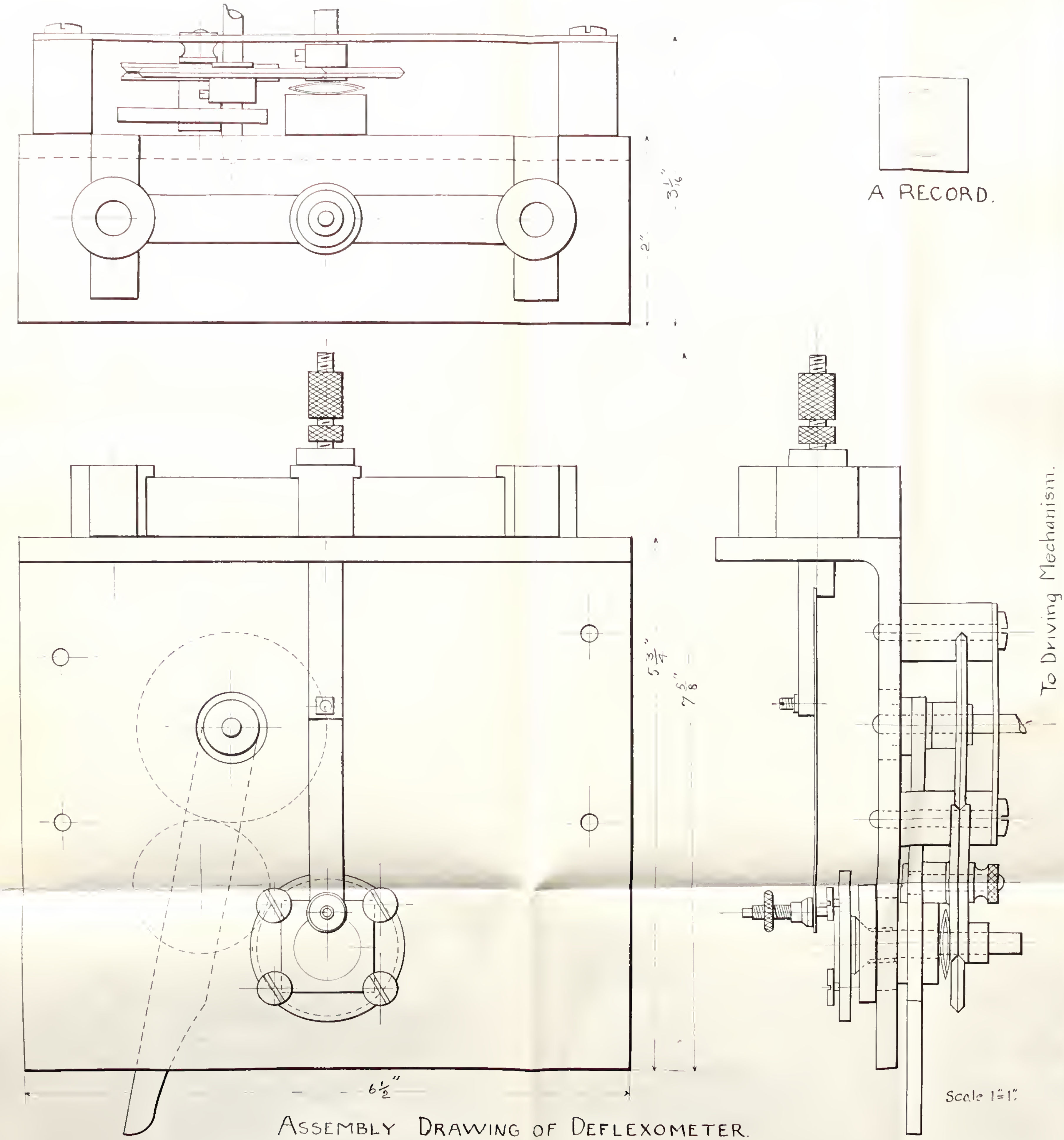
Another very desirable thing would be to have a Deflectometer as described in this thesis, made by an expert scientific instrument maker. Then this method of testing for microscopic deflection would be an extremely accurate one.

TABLE I.

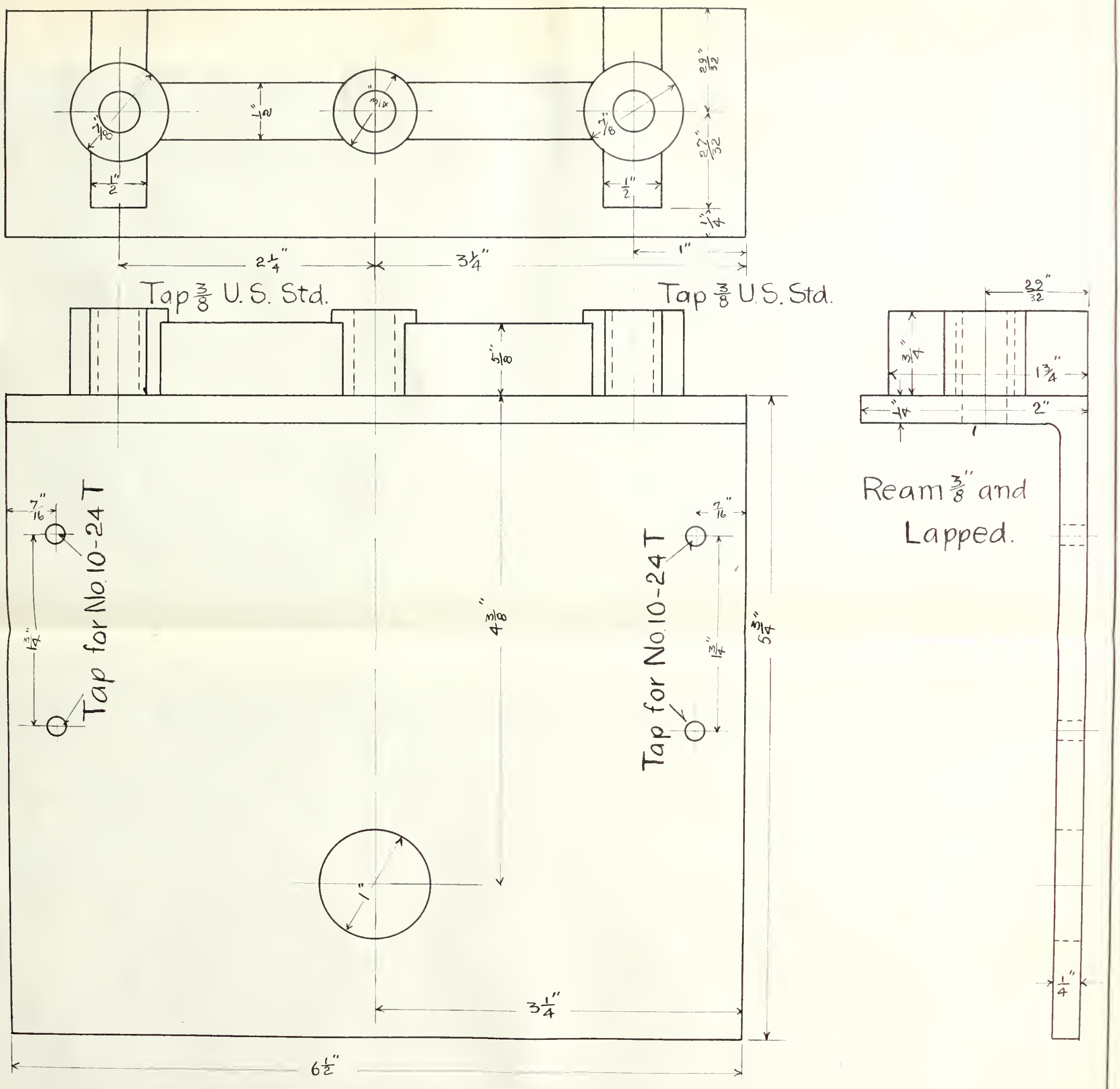
No. of test.	Depth of cut in inches.	Feed in ft. per minute.	Cutting speed ft. per minute.	Deflection in inches. Maximum	Deflection in inches. Average	Remarks.
1	.125	.1094	50	.000984	.000824	Vibrations frequent, but do not cross datum.
2	.150	.1042	40	.000615	.000410	Some vibrations crossing datum.
3	.225	.0417	20	.000492	.000332	Some vibrations cross datum.
4	.150	.6775	25	.000738# .001845#	.000541	See foot note.
5	.150	.09375	32			Record is too coarse, the two lines overlap.
6	.150	.1466	45	.000615	.000369	Vibrations cross datum most of time.

Note: The low value is the maximum deflection for the smooth portion of the graph. The large one is the length of the maximum chatter mark.


RECORD.
echanism.

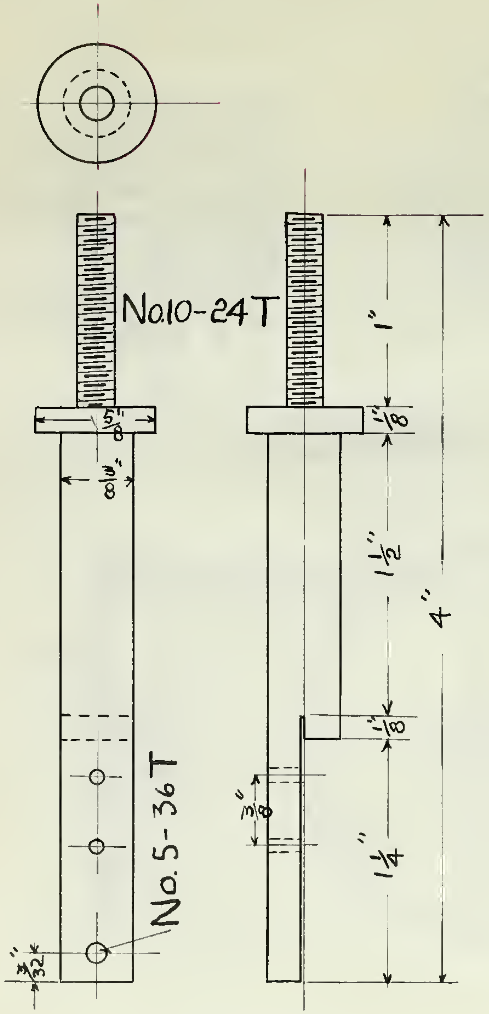


ASSEMBLY DRAWING OF DEFLEXOMETER.

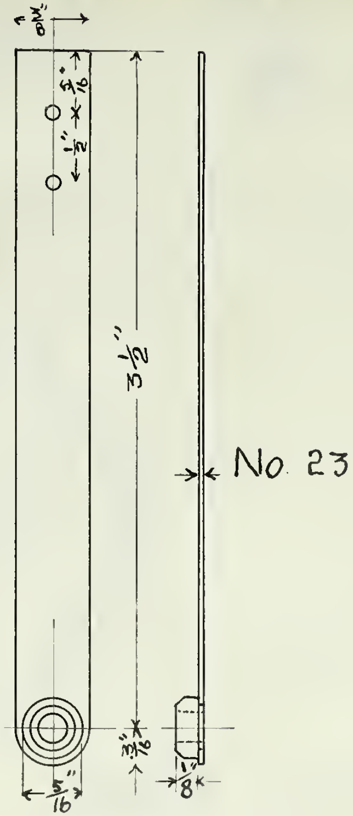


Frame.

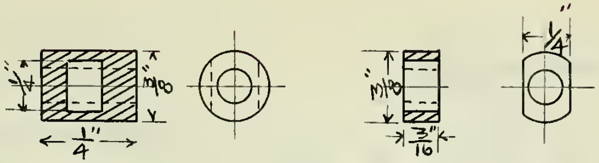
Scale: 1" = 1"



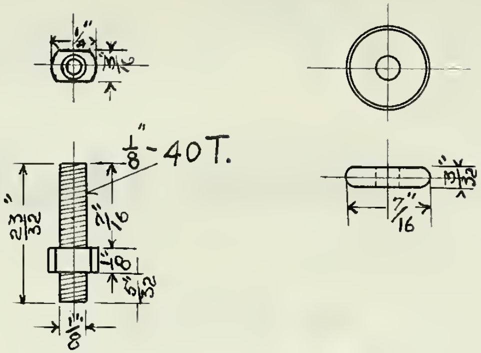
PLUNGER.



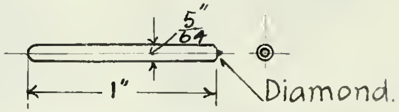
PLUNGER SPRING.



PLUNGER NUT AND LOCK NUT.

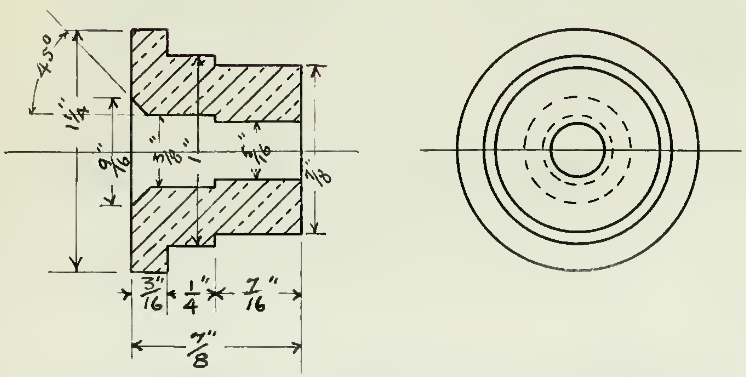


SCRIBE HOLDER.



SCRIBE.

Scale: 1"=1".



BEARING.

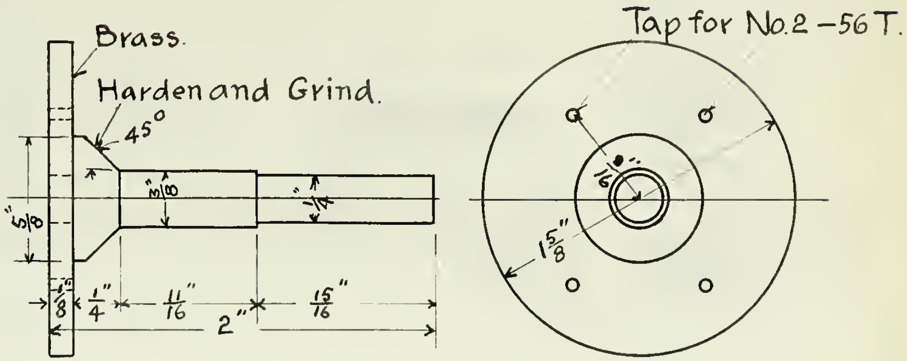
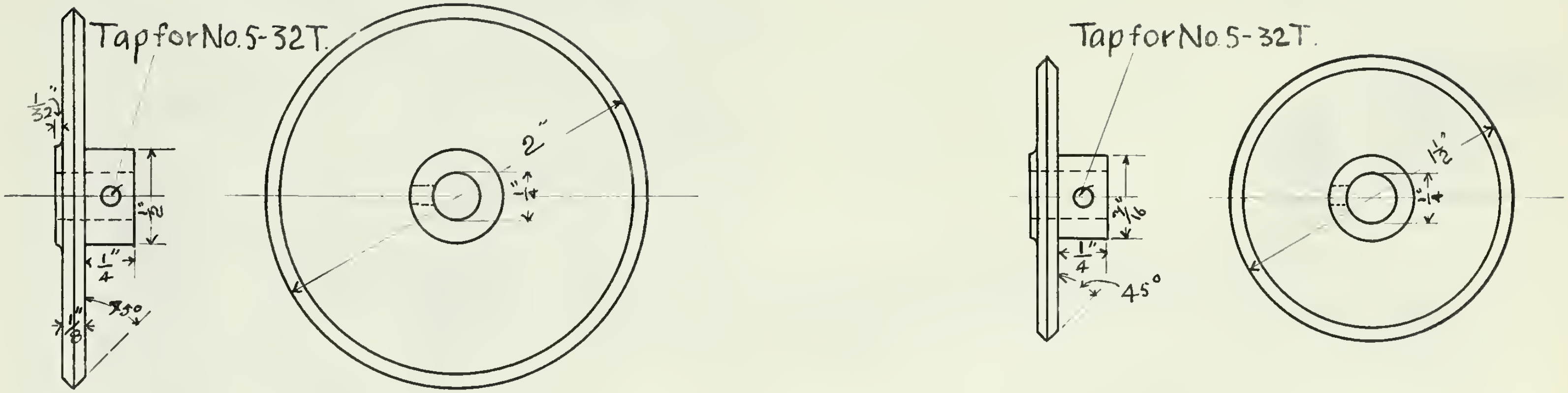
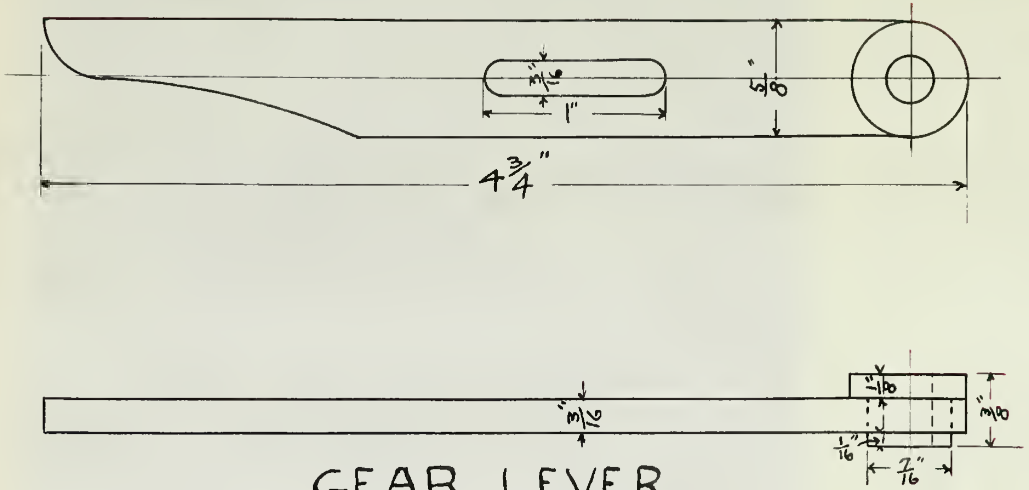


PLATE HOLDER.

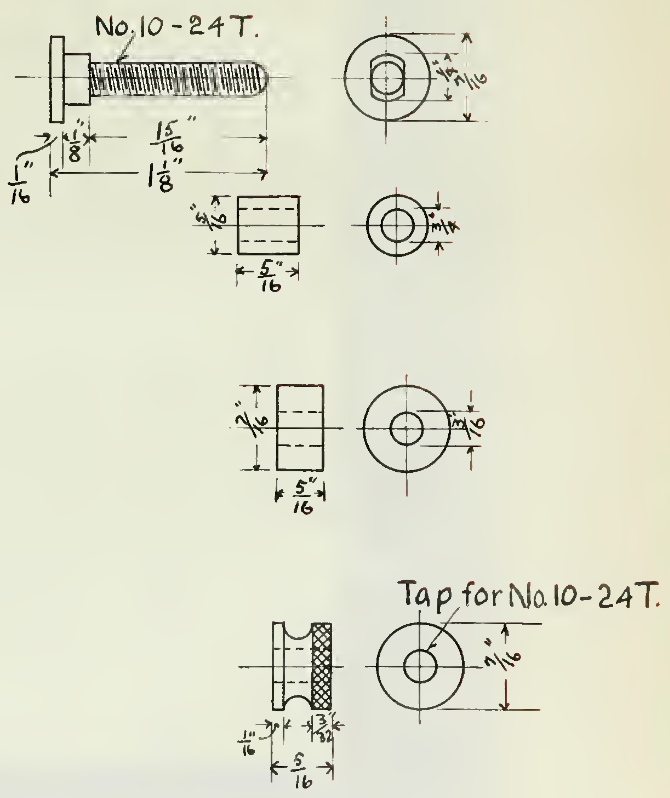


BRASS FRICTION GEARS.

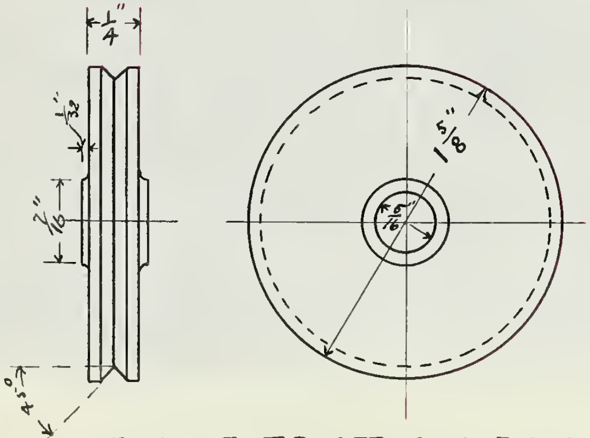
Scale: 1"=1".



GEAR LEVER.



STUD.

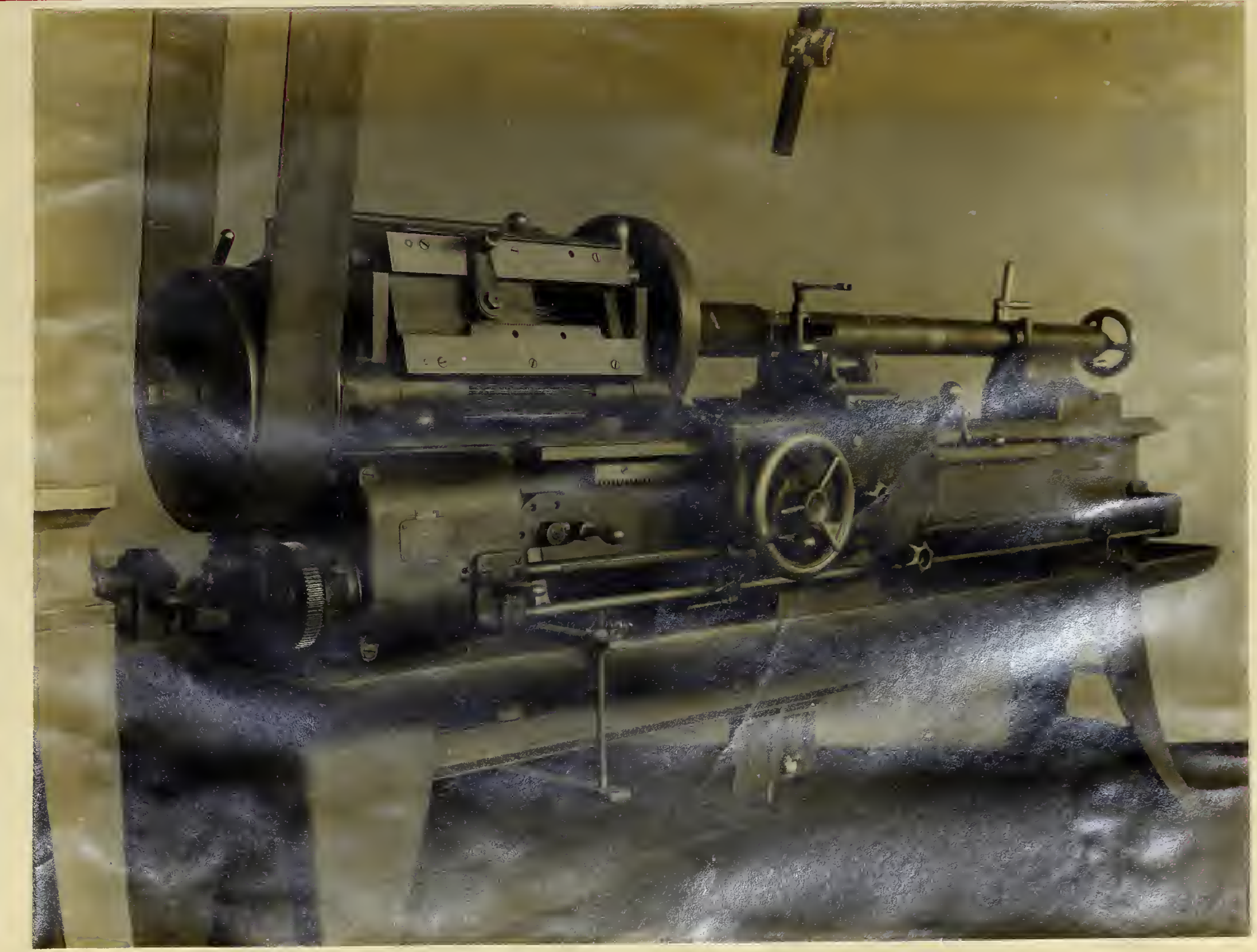


FIBRE FRICTION GEAR.

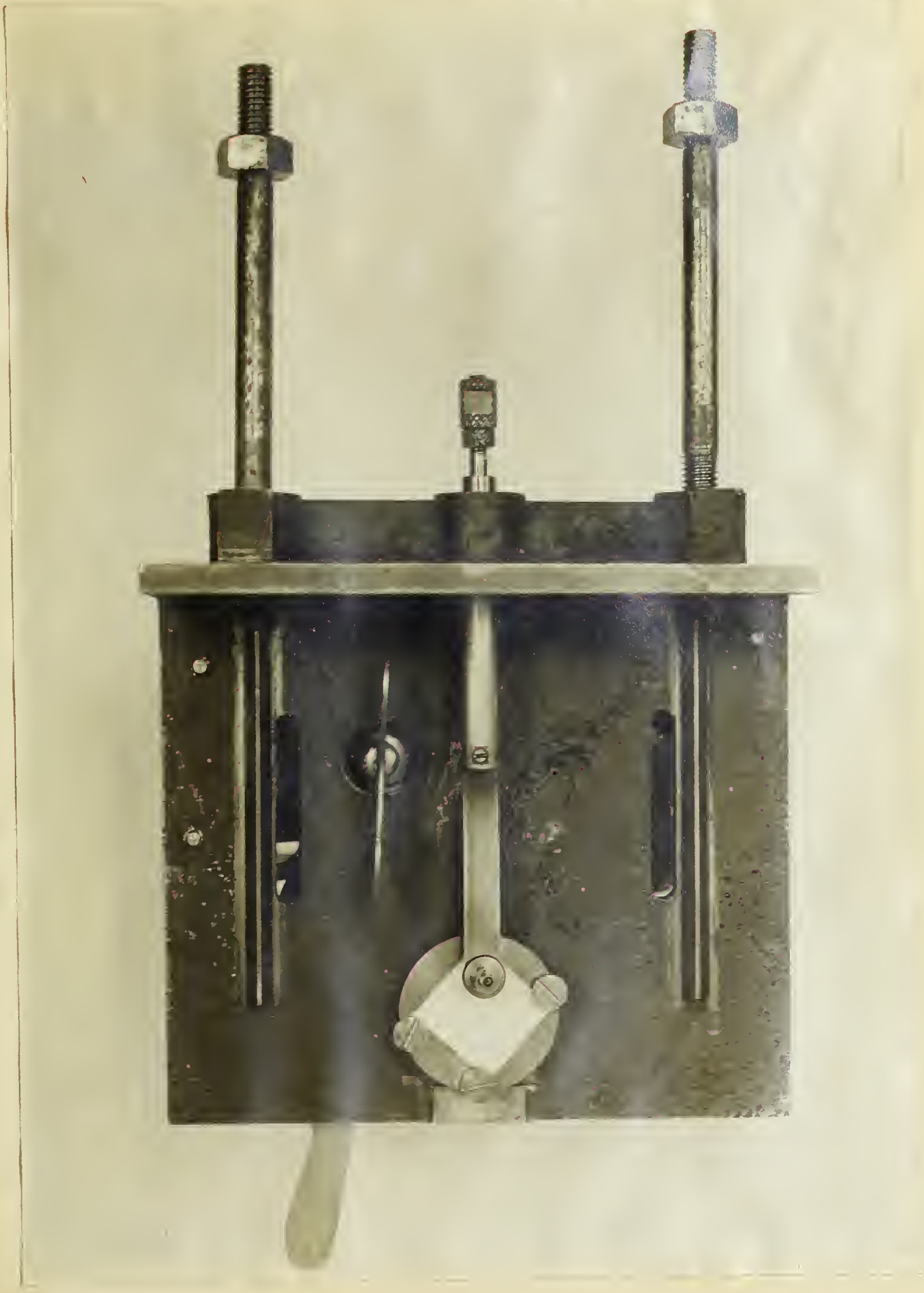
Scale: 1"=1".

Note:- Another page of photographs is to be included in this thesis. These are to be magnified reproductions of deflections. Dr. Hottes of the Botany department, who has promised to help me with these, has not yet been able to find time.

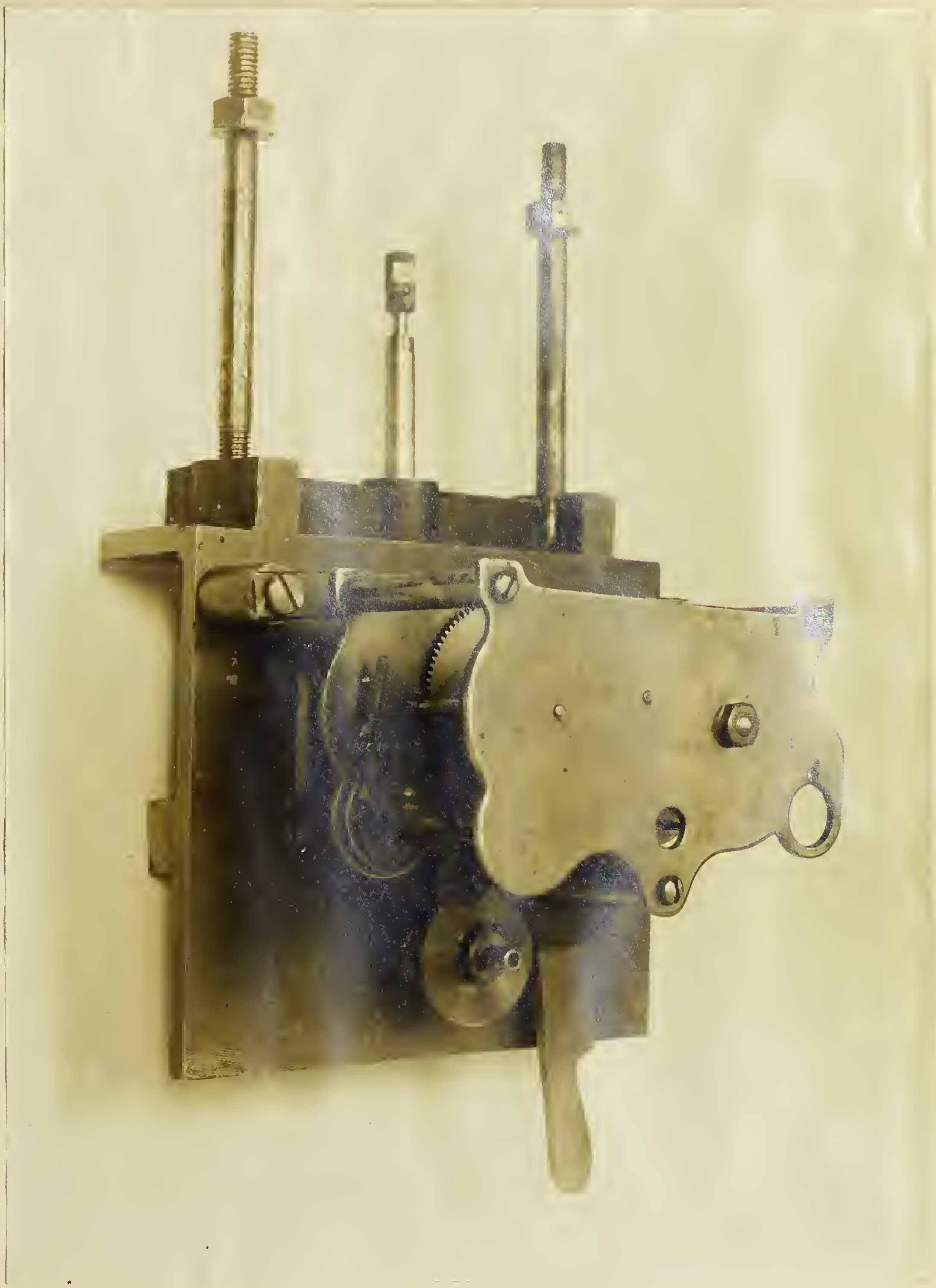
Ferdinand J.



DEFLEXOMETER IN USE ON THE PRATT AND WHITNEY LATHE.



DEFLEXOMETER   FRONT VIEW.



DEFLEXOMETER REAR VIEW

UNIVERSITY OF ILLINOIS-URBANA
3 0112 079094162